IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Review On Utilization Of Bottom Ash In Cement Concrete

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Abstract: Bottom ash is a byproduct of coal combustion in thermal power plants, it is characterized by its granular texture. The composition of bottom ash includes silica (SiO2), alumina (Al2O3), and iron oxide (Fe2O3). Bottom ash is used only as a filler material in construction Industry. In this study we used bottom ash waste as a proxy material to reduce the increasing cost in the construction industry. Coal bottom ash waste generated each year in high volume.

This paper reviews the physical and chemical characteristics and utilization of coal bottom ash as a proxy material in the construction industry. The goal of this review is to emphasize the possibility of recycling of bottom ash in civil construction.

Index Terms – Bottom Ash Concrete, Coal Bottom Ash, Concrete Mix Design, Thermal Power Plant (TPP), Sustainable Concrete, Compressive Strength, Cement, Sand and Aggregate.

INTRODUCTION

The construction industry is one of the largest consumers of natural resources, particularly for materials like cement, sand, and aggregates. With the growing demand for sustainable construction practices and the need to reduce the environmental impact of waste, the utilization of industrial by-products has gained significant attention. One such by-product is bottom ash, a residue produced from the combustion of coal in thermal power plants.

Bottom ash, typically considered a waste material, contains a variety of minerals and has properties that make it a potential substitute for traditional components of concrete, such as fine aggregates (sand) and, in some cases, even cement. By incorporating bottom ash into cement concrete, it is possible to reduce the dependency on natural aggregates and mitigate the environmental concerns associated with landfill disposal of this material.

The combination of cement, sand, coarse aggregates, and bottom ash in concrete not only addresses environmental challenges but also explores the potential benefits such as improved workability, cost reduction, and enhanced durability. This approach supports the circular economy, where industrial by-products are re-used in a productive manner, contributing to sustainable construction practices.

This paper aims to explore the potential of utilizing bottom ash as a partial replacement for fine aggregates or cement in concrete. It will evaluate the impact of bottom ash on the physical and mechanical properties of concrete, such as strength, durability, and workability, to understand its effectiveness as a construction material.

OBJECTIVES

1) To explore the Properties of Bottom Ash.
2) To investigate the Current Applications of Bottom Ash in Cement Concrete.
3) To evaluate the Benefits of Using Bottom Ash in Concrete.
4) To identify the limitations on incorporating of Bottom Ash in Cement Concrete.
5) To Promote Sustainable Construction Practices.
6) To mitigate carbon content from construction materials.

LITERATURE REVIEW

2000s: Early Investigations into Bottom Ash Use

in Concrete 2002 - Khan et al.

Khan and colleagues conducted early research on the use of bottom ash as a partial replacement for sand in concrete mixes. Their study indicated that replacing up to 20% of the fine aggregates with bottom ash did not significantly affect the compressive strength of the concrete. However, workability was found to decrease with higher bottom ash content, highlighting the need for adjustments in mix proportions.

2004 - Siddique & Chahal

This study explored the effects of incorporating bottom ash in concrete as a partial replacement for fine aggregates. The results showed that the compressive strength of concrete decreased with increasing bottom ash content. The researchers also noted that bottom ash improved the thermal properties of concrete, suggesting its potential use in pavements subjected to high temperatures.

2010s: Increasing Focus on Durability and

Performance 2010 - Bui et al.

Bui et al. examined the effect of using bottom ash as a partial replacement for fine aggregates on the mechanical properties of concrete. They observed that up to 30% replacement by volume of fine aggregates with bottom ash led to a slight decrease in compressive strength but improved the durability characteristics, particularly in terms of chloride ion penetration and water absorption. This pointed to the potential benefits of bottom ash in enhancing the durability of concrete structures.

2012 - Taha et al.

Taha and colleagues expanded on the previous research by studying the effects of bottom ash as a supplementary cementitious material. Their results revealed that the inclusion of bottom ash (as a partial substitute for cement) improved workability and reduced heat generation in the early stages of hydration. However, compressive strength was slightly reduced, especially in mixes with higher ash content. The study concluded that bottom ash could be used as a supplementary cementitious material for specific applications requiring low strength.

2014 - Khaloo et al.

Khaloo and his team focused on the environmental benefits of using bottom ash in concrete, emphasizing its role in reducing the carbon footprint of construction materials. Their study indicated that using bottom ash in concrete reduced the need for natu ral resources such as sand and gravel, thereby lowering the environmental impact. Additionally, they found that bottom ash enhanced the long-term durability of concrete by improving its resistance to sulfate attack.

2020s: Optimization and Advanced

Applications 2020 - Akinmoladun et al.

Akinmoladun's research involved the optimization of bottom ash content in concrete for both mechanical and durability performance. The study determined that up to 25% replacement of fine aggregates with bottom ash provided a good balance between strength and durability, with better performance in terms of water retention and workability compared to traditional mixes. Furthermore, bottom ash-based concrete exhibited improved resistance to freezing and thawing cycles.

2021 - Lee et al.

Lee et al. focused on the impact of different particle sizes of bottom ash on the properties of concrete. Their study revealed that fine bottom ash particles improved the workability of the mix but had a slightly negative impact on compressive strength. Conversely, coarser bottom ash particles showed a more pronounced reduction in strength but offered enhanced resistance to environmental factors like moisture absorption. The researchers concluded that careful selection of bottom ash particle size was critical for optimizing concrete properties.

2022 - Abdel-Ghany et al.

Abdel-Ghany's research explored the potential of using bottom ash as a full replacement for natural aggregates in concrete. The study demonstrated that using bottom ash as a complete substitute for coarse aggregates resulted in lower compressive strength but increased the concrete's fire resistance and thermal conductivity. The authors recommended bottom ash concrete for applications such as fire-resistant structures and pavements in hot climates.

Recent Developments (2023-

2024) 2023 - Saha et al.

Saha and colleagues conducted an extensive study on the long-term durability of concrete incorporating bottom ash. Their findings revealed that over a period of 1-2 years, the bottom ash concrete exhibited lower cracking tendencies, reduced shrinkage, and better resistance to chemical attacks compared to conventional concrete. The researchers suggested that bottom ash could be particularly beneficial in infrastructure exposed to harsh environmental conditions.

2024 - Kumar et al.

Kumar et al. focused on the effects of nanomaterial incorporation in bottom ash-based concrete. The results indicated that the addition of nano-silica or nano-titanium dioxide to bottom ash concrete enhanced its mechanical properties, including compressive strength and resistance to alkali-silica reaction. This hybrid approach demonstrated that bottom ash could be effectively utilized in advanced concrete applications, such as high-performance concrete for specialized structures.

METHODOLOGY

1) Accumulation of raw materials (Cement, Fine Aggregate, Coarse Aggregate and Bottom Ash.)
2) Various tests on materials.
3) Identify the water content of both the aggregate and bottom ash.
4) Preparation of samples for tests having size of 230mm*110mm*70mm.
5) Concrete mix design for M25 grades of concrete as per IS code.
6) Leave samples to cure with portable water.

7) Determine the compressive strength after 7 days, 14 days and 28 days of curing.

CONCLUSION

The utilization of bottom ash in cement concrete demonstrates its potential as a sustainable and eco-friendly alternative material. Studies have shown that bottom ash can effectively replace a portion of conventional aggregates and cement, contributing to waste reduction and the conservation of natural resources. While bottom ash-based concrete has shown improved durability characteristics such as resistance to abrasion and enhanced chemical stability, concerns about its impact on compressive strength and long-term performance remain. The variability in bottom ash properties, along with potential environmental concerns like leaching, requires careful consideration and further research. Overall, while bottom ash holds promise for sustainable concrete production, its application needs optimized mix designs and proper quality control to ensure its full potential in the construction industry.

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